AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



MARK SCHEME

4.4.4 NUCLEAR FISSION AND FUSION (PACK 2)

SCORE	PERCENTAGE
/100	%

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Q1.

(a) (i) (nuclear) fusion

*allow minor misspellings but do **not** credit any response which could be fission*

1

(ii) (in) stars

accept supernova / red giants / white dwarves

*do **not** allow the Sun*

1

(iii) (by) supernova / explosion of star

*do **not** credit just 'explosion(s)'*

1

(b) the (available) evidence:
supports this idea
or does not contradict this idea
or can be extrapolated to this idea

1

[4]

Q2.

The answer to this question requires ideas in good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme.

*Maximum of **1** mark if ideas not well expressed*

any **two** from:

dust <u>and</u> gas **or** remnants of a super nova

accept hydrogen for dust and gas
*do **not** accept hydrogen burns*

pulled together by (force of) <u>gravity</u>

nuclear fusion starts

although candidates may include more detail these points are essential to score the credit

[2]

Q3.

(a) (i) (large) <u>nucleus</u> hit by a neutron

1

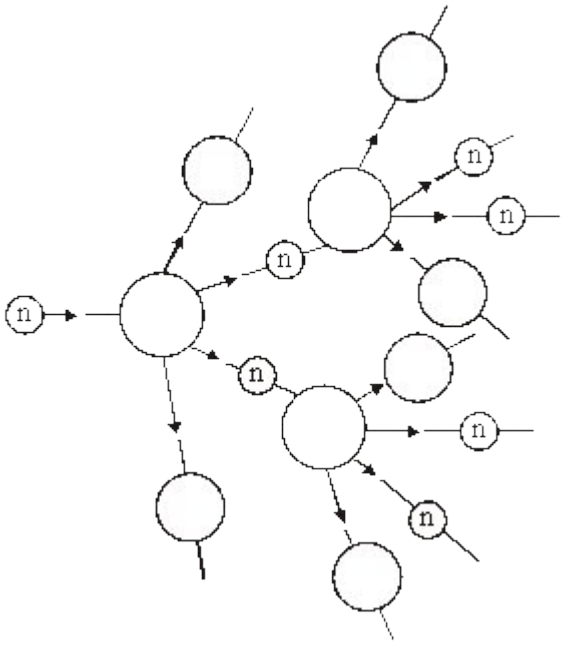
splits into (smaller) nuclei **and** neutron(s) (+ energy)

1

(ii) additional neutrons collide with nuclei causing further fission

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allow full credit for a correct labelled diagram
accept 2 or more neutrons given out at each fission reaction
diagram shows 3 discernible sizes, with smaller nuclei and neutrons at same stage



1

(b) cost of (building and) de-commissioning is very high **or**
cost of building is higher

accept a correct description of de-commissioning
accept high cost to keep the power station safe / secure
accept high cost of reprocessing / storage of nuclear waste

1

(c) less pollution from transport carrying the fuel

accept coal produces more pollutant gases
accept correct named gases
accept more radiation pollution from coal than nuclear
accept more waste from coal than nuclear
*do **not** accept any reference to burning uranium*
*do **not** accept answers in terms of global warming **or** acid rain unless developed*

1

[5]

Q4.

(a) any **two** from:

- nuclei / atoms of light elements fuse

accept hydrogen or helium for light elements
accept join for fuse
*accept for **1** mark, by nuclear fusion*
answers about fission negates a mark

- each (fusion) reaction releases energy / heat / light

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- lots of reactions occur

2

(b) presence of nuclei of the heaviest / heavy / heavier elements

accept atom for nuclei

1

(c) (i) (matter / mass) with such a high density / strong gravitational (field)

1

electromagnetic radiation / light is pulled in

accept nothing can escape
*do **not** accept answers in terms of an empty void*

1

(ii) X-rays

accept e-m radiation / e-m waves

1

[6]

Q5.

(a) (i) both lose 2 protons and (2) neutrons

accept changes by 2 protons and 2 neutrons

1

(ii) different number of protons (in the nucleus)

accept different atomic number
*do **not** accept different number of protons and neutrons or different mass number*
ignore electrons

1

(iii) gamma involves no change in the number of protons (in the nucleus) **or** gamma is a wave (not a particle)

*do **not** accept number of neutrons and / or protons*
ignore electrons

1

(b) (i) water because

*both material **and** reason required*

for all energy values the thickness of water needed to absorb (90% of) the radiation is more than the other materials

accept thickness of water required is always more than the other materials

1

(ii) 6

*allow **1** mark for obtaining both correct values 72 **and** 12 from graph*
*allow **1** mark for incorrect values 71 and / or 11 from graph evaluated correctly*

2

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(c) any **three** from:

may be scored on annotated diagram provided not negated elsewhere

- most (alpha) particles passed undeflected / straight through the gold
- suggesting most of the atom is empty (space)
- a few (alpha) particles scattered / deflected through (very) large angles

  accept repelled
  *do **not** accept reflected / rebound / bounce back*
- suggesting a concentrated / small nucleus
- nucleus is positive because it repels the positive (alpha) particles

  *no reference to experiment, maximum **1** mark*

3

[9]

Q6.

(a) fusion

accept fussion

1

energy producing process

accept heat and/or light for energy
accept fussion

1

(b) up to **2** points from:

***3** marks for 3 points in sequence with no contradiction*

- expands

  ***2** marks for 2 points in sequence with no contradiction*
- cools
- forms a red giant

  ***1** mark for a correct point which is not contradicted*

up to **2** points from:

*do **not** accept 'it turns red'*

- contracts
- increases in temperature
- forms a white dwarf

  ignore further reference to black dwarfs, black holes, nebulae, supernovae

3

[5]

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Q7.

(a) (i) centre

1

(ii) protons and neutrons

2

(iii) different number of neutrons

gets 1 mark

heavier

gets 1 mark

3 more neutrons or specified numbers

gets 2 marks

2

(b) atom hit by neutron;
splits into smaller nuclei;
further neutrons released;
neutrons released when one atom splits
cause further fission;
energy released.

any 4 for 1 mark each

4

[9]

Q8.

(i) sensible answers e.g. risk of radioactive leak during transport eliminated
cheaper transport

1

(ii) 4 half-lives 4 × 6 = 24 seconds

3

[4]

Q9.

(i) the nuclei
of hydrogen/smaller atoms
join to make helium/larger atoms

for 1 mark each

3

(ii) the mass of the large nucleus (atom) is less than the mass of the smaller nuclei (atoms)

for 1 mark

mass loss converted into energy or small mass loss given a large amount of energy

for 1 mark

2

[5]

Q10.

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(a) the Sun is subject to two balancing forces / 2 forces in equilibrium
the forces are: gravity making it contract **or** inward force due to gravity
and a force due to temperature / heat / energy / radiation pressure making it expand **or** outward force due to temperature / heat / energy / radiation pressure

for 1 mark each

3

(b) Read all the answer first. Stop after 6 marks.

hydrogen / fuel used up owtte the star will expand and become a red giant
it will contract under gravity become a white dwarf
it may explode and become a supernova throwing dust and gas into space
leaving a dense neutron star / black hole

(no mark for contradiction)
any six for 1 mark each

6

[9]

Q11.

any **three** from

max 2 if stages but no explanation

- the star (Sun) expands because
(inward) gravitational forces no longer balance (outward) force

  accept the star collapses rapidly causing the core temperature to increase and the star to expand
  accept it expands because the forces are unbalanced

- to become a red giant

- when the fusion stops it contracts / cools

  accept (when hydrogen is used up) it collapses under gravity
  accept when fusion stops it contracts and explodes

- to become a white dwarf

  accept to become a supernova / pulsar / neutron star / black hole (only if red giant has exploded)

[3]

Q12.

(a) (i) any **two** from

(matter from) exploded star / supernova

matter so dense / gravity so strong

that electromagnetic radiation / light cannot escape from it

2

(ii) X-rays emitted

1

when gases or matter released from nearby stars spiral into it

1

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(b) fusion (of nuclei)

1

of lighter elements / hydrogen helium

1

[6]

Q13.

Quality of written communication: One mark for using correct scientific sequence : gravity → fusion → balance

1

any **four** from

- (dust and gas) pulled together by gravity
- (star formed when) it is hot enough
  accept (as mass is pulled together) it gets very hot
- hydrogen (and helium) nuclei fuse
- (these nuclear fusion reactions) release the energy / heat / light (which is radiated by stars)
- energy causes expansion
- gravitational pull is balanced by the expansion (force)

4

[5]

Q14.

(a) materials produced when earlier stars exploded

accept the Sun is a second generation star

accept formed from nebulae

1

(b) **Quality of written communication:**
1 mark for correct sequencing balanced forces → expansion → contraction / explosion

1

any **five** from

gravity pulling matter together

accept idea that a star is very massive so its force of gravity is very strong

high temperatures that create expansion forces

nuclear fusion releases energy that causes the very high temperatures

these forces balance

star expands greatly

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since expansion is greater than gravity

accept fuel runs out

forms a red giant

give no further marks if red giant → white dwarf, red dwarf etc

collapses inwards and explodes outwards

called a supernova

neutron star may form

leaves a small, dense object (a black hole)

accept nothing can escape from it

5

[7]

Q15.

any **one** of

* between (stage) 2 and (stage) 3
* (in) the main sequence
* (in) the main stable period
* (it is a) yellow dwarf

[1]

Q16.

(a) *evidence of conclusion* 4 × 1.007825 **or** 4.0313

each gain 1 mark

based on use of data that there is a (very small) loss of mass **or** 0.0276 **but** a loss of mass of 0.0276 **for every helium atom or** 0.69%/0.7%

gains 3 marks

3

(b) *idea that* loss of mass results in release of energy

gains 1 mark

but small loss of mass results in huge energy release

gains 2 marks

2

[5]

Q17.

(a) it use $E = mc^2$

mass in kg i.e. $0.001 \times \frac{0.7}{100}$

each gains 1 mark

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but 000007

gains 2 marks

2.1×10^3

gains 3 marks

evidence of 0.000007

mass in kg (i.e. 0.0007 **or** 0.7/100000)

each gains 1 mark

squaring the speed of light
but 6.3×10^{11} *(credit alternative ways of stating this)*

gains 3 marks

units J/joule

for 1 further mark

(N.B credit kJ, MJ, GJ but check power of 10 for full credit)

4

(b) (i) *idea that* the bigger the mass the shorter the life

gains 1 mark

but *idea that* decrease in life is much more than proportional to increase in mass
or more than proportional to mass^2

gains 2 marks

2

(ii) *ideas that*:
greater mass means greater **core** temperature/pressure
greater core temperature/pressure means greater rate of fusion
increase in mass produces a proportionally much greater increase in the rate of fusion

each for 1 mark

3

[9]

Q18.

ideas that

- formed from dust/gases
- pulled together by gravity
- massive so very large gravitational forces (pulling inwards)
- hydrogen → helium / fusion releases energy [<u>not</u> fission or just 'nuclear']
- high temperature creates high pressure (pushing outwards)
- long period when forces balance
- then expands → red giant / red star

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• then contracts to (dense) white dwarf / white star

[credit if massive enough / more massive than sun, red giant → supernova → (very dense) neutron star but do not accept w.r.t. Sun itself]

[The whole of the (non bracketed part of) each idea must be present in some appropriate for in of words for each mark to be credited. To gain more than a single mark ideas must also be in correct sequence and/or appropriately related.]

any six 1 mark each

[6]

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